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THE PHOTOMETRIC PERIOD OF V1974 CYGNI (NOVA CYGNI 1992)

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ABSTRACT

We present the discovery of the photometric (orbital) period for V1974 Cygni (Nova Cygni 1992). The orbital period of 0.081263 ± 0.000003 days places this classical nova just below the catalysmic variable (CV) period gap. The modulation is driven by irradiation by the white dwarf (WD) heating one hemisphere of the red secondary and its aspect changes during orbital revolution.

Subject headings: binaries: close — novae, cataclysmic variables — stars: individual: (V1974 Cygni)

1. INTRODUCTION

Nova Cygni 1992 was discovered while still rising toward maximum at a visual magnitude of 7.2 by AAVSO member Peter Collins on 1992 February 19.1 (Collins 1992a, b). The nova reached a visual light maximum of ∼4.3 mag on 1992 February 22. A potential pre-nova candidate was found on the Palomar Observatory Sky Survey (POSS) prints (Skiff 1992). Due to positional discrepancies of over 2 arcseconds the POSS pre-nova candidate may not be the true precursor (Pavelin et al. 1993) which then implies a range of at least 16 magnitudes. We estimate the distance to the nova as 2.3 ± 0.5 kpc based on a simple average of optical interferometric and direct angular imaging, radio angular measures, and photometric measurements reported (Hayward et al. 1992; Andrillat & Houziaux 1993; Barger et al. 1993; Chochol 1993; Paresce 1994; Pavelin et al. 1993; Quirrenbach et al. 1993). The nova is an ONeMg "neon nova" as suggested by or confirmed by many authors (Austin et al. 1992; Shore et al. 1992; Emerson & Mannings 1992). It was also detected as a strong soft X-ray source with a hard spectrum by *ROSAT* with a flux of 2×10^{-13} ergs s^{-1} in the 1 to 2 keV energies (Krautter, Ogelman, & Starrfield 1992).

The orbital period is an important physical parameter that allows the mass and radius of the components to be determined when combined with time-resolved spectroscopic radial velocity observations. Future studies of the secular evolution of the orbital period will be aided with a good initial orbital period determination.

2. OBSERVATIONS

A total of 1876 CCD images were obtained of V1974 Cyg over 25 nights during the period 1993 October 6.99 to 1993 December 10.05. During this interval the nova was approximately 12.8 mag visual as determined from IAU Circular and AAVSO Circular data. The telescope employed was the 0.61 meter cassegrain reflector located at the US Naval Observatory in Washington, DC. A Photometrics Ltd camera system based on a Thomson-CSF THX31156 1024 × 1024 front-illuminated CCD was used. The CCD was binned on-chip by a factor of 2 × 2, yielding 0.94 arcsecond pixels. The filters used were a Kron-Cousins I filter [RG9(4.4 mm)], a Johnson V filter [GG495(2.6 mm) + BG39(1.8 mm)], and a clear filter [WG80(4.4 mm)]. The number of observations in each filter were 1,625 in I, 142 in V, and 109 in the clear filter. All the photometry was left in the instrumental system. Synthetic aperture photometry was extracted from flatfielded images using DAOPHOT (Stetson 1987). The reference ensemble was formed from a group of seven bright constant stars in the field.

The I band light curve shows a modulation of 0.16 ± 0.05 mag, with a slight asymmetry where the rise is faster than the fall, i.e., an M-m ratio of 0.42 (Fig. 1). The normalized V band light curve shows a very weak modulation of 0.05 ± 0.06 mag (Fig. 2) and the instrumental $V-I$ light curve shows a modulation of 0.10 ± 0.08 mag (Fig. 3). It is interesting to compare the light curve of RW UMi (Nova UMi 1956) which has a photometric period of 0.081 ± 0.003 days and a similar peak-to-peak amplitude (Szkody et al. 1989).

The heliocentric times of minima were determined by a numerical differencing method (Kwee & van Woerden 1956). A linear least-squares fit to 26 times of minima, standard error of estimate of 0.0037 day, produces the following ephemeris for the photometric variation:

$$\begin{aligned} \text{Min.(HJD)} &= 2449267.562 + 0.081263 * E \\ &\quad \pm 0.001 \pm 0.000003 \,. \end{aligned} \tag{1}$$

Figure 4 shows the O-C residuals from the above linear fit. Searches were made for possible beat periods caused by asynchronous WD rotation with respect to the orbital revolution using the phase-dispersion-minimization method (Stellingwerf 1978). No evidence of other significant periodic phenomena in any color was found in a search of periods from 0.1 to 10.0 days. There is no evidence of eclipses at the same level.

3. DISCUSSION

The photometric period and its stability strongly suggests one directly related to the orbital period of the binary system. The orbital period determined for V1974 Cygni is on the short-period edge of the CV period gap. Interestingly, the orbital period determined is very near the polar (AM Her) cluster period of 0.08125 days (Cropper 1990).

We interpret the light and color variations as being caused by aspect changes during the orbital revolution of a radiationally heated hemisphere of the secondary by the hot WD, see Kovetz, Prialnik, & Shara (1988) for a theoretical discussion. The instrumental $V-I$ light curve shows a color variation with phase which is consistent with the secondary being the source of the light and color variation and not a hot spot. The asymmetry of the I band M-m ratio of the light curve is interpreted as coming from differential rotation of the sec-

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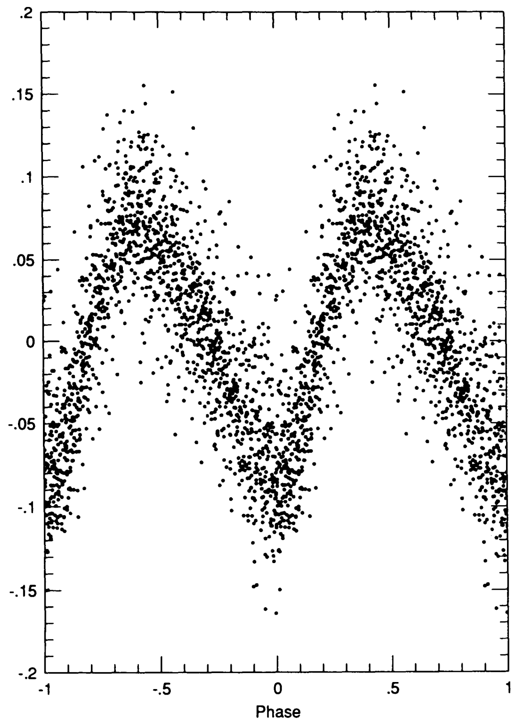

FIG. 1.—Normalized instrumental I light curve vs. photometric phase as determined from eq. (1). The normalization was performed by determining a nightly mean and correcting each point by that amount. Each individual magnitude measure is shown. The rms scatter of a single point is ± 0.05 mag and was determined from the first differences of the magnitudes sorted by phase. Two full cycles are shown.

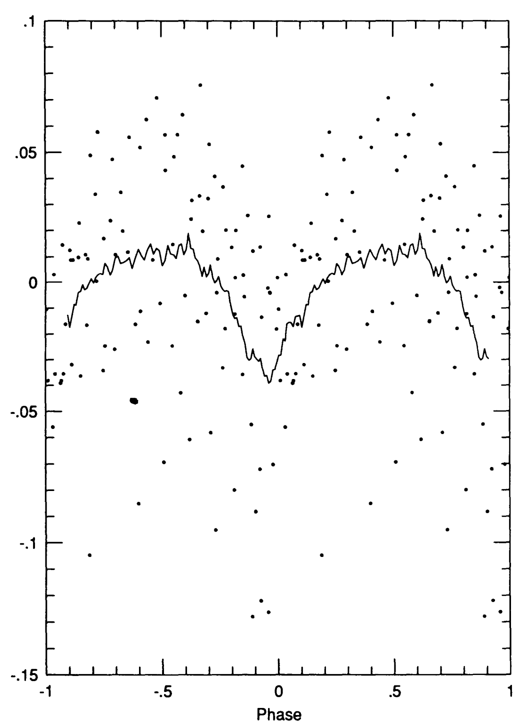

FIG. 2.—Normalized instrumental V light curve vs. photometric phase as determined from eq. (1). The normalization was performed in the same manner as Fig. 1. Each individual magnitude measure is shown. The rms scatter of a single V point is ± 0.06 mag and was determined from the first differences of the magnitudes sorted by phase. The phase sorted data was smoothed by generating a running mean using 20 points and is indicated by the line. Two full cycles are shown.

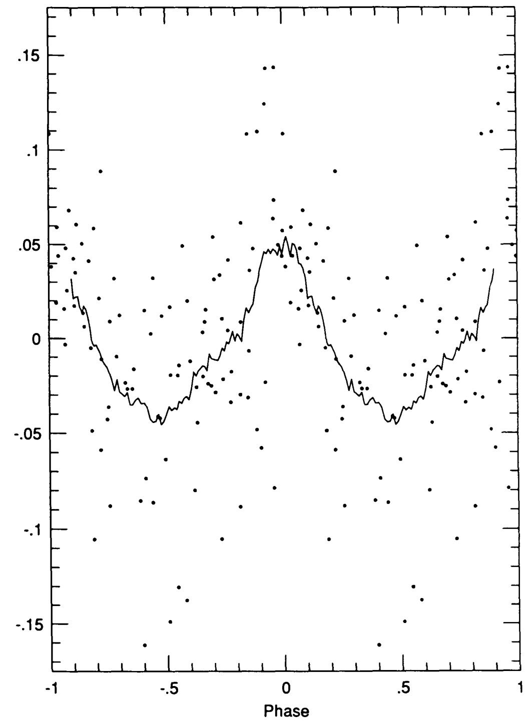

FIG. 3.—Normalized instrumental $V-I$ light curve vs. photometric phase as determined from eq. (1). The normalization was performed in the same manner as Fig. 1. A single point is the result of a single I-V-I combination where the I-values were averaged. The rms scatter for a single point is ± 0.08 mag and was determined from the first differences of the magnitudes sorted by phase. The phase sorted data was smoothed by generating a running mean using 20 points and is indicated by the line. Two full cycles are shown.

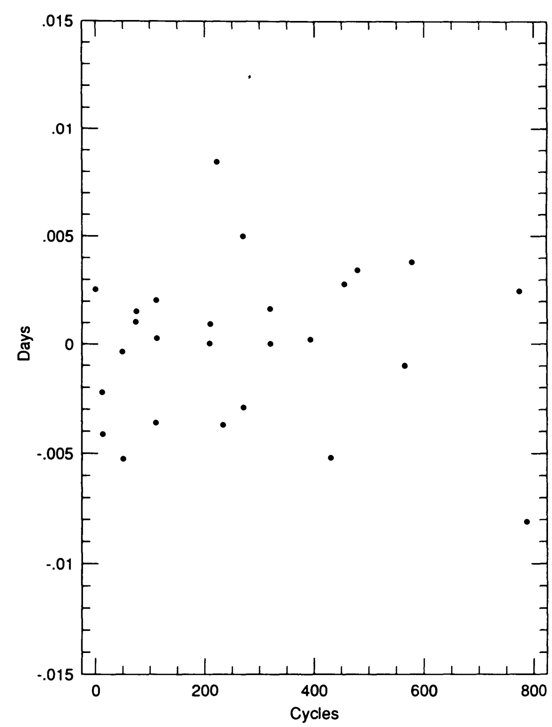

FIG. 4.—$O-C$ diagram for the times of minima computed from eq. (1)

ondary spreading the heated atmosphere into a tear-drop shape and/or from the nonspherical shape of the secondary.

4. CONCLUSION

We have discovered the photometric period of 0.081263 ± 0.000003 days for V1974 Cygni which we interpret as the orbital period. The light modulation comes from the heated secondary and its aspect changes during the orbit.

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